

*IMPLICATIONS OF BEHAVIORAL PHARMACOLOGY RESEARCH FOR
APPLIED BEHAVIOR ANALYSES: JEAB'S SPECIAL ISSUE CELEBRATING
THE CONTRIBUTIONS OF JOSEPH V. BRADY (MARCH 1994)*

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We review four articles from *JEAB*'s March 1994 issue celebrating the contributions of Joseph V. Brady. These articles have implications for studying private events and for studying multiple operants. We suggest that regularly including self-reports about private events in behavioral pharmacological research has resulted in an accumulated knowledge that has facilitated examination of interesting relations among self-reports, environmental factors, and other observable behaviors. Methodological lessons that behavioral pharmacologists have learned regarding the study of multiple operants are also relayed. We provide examples of how these lessons could be useful to applied behavior analysts studying nonpharmacological issues.

DESCRIPTORS: *Journal of the Experimental Analysis of Behavior*, measurement, methodology, recording and measurement, self-reports

JEAB's special issue celebrating the contributions of Joseph Vincent Brady (March 1994) testifies to the breadth of Brady's influence on the study of human behavior by bringing together research from diverse sources. This collection of 17 papers presents research investigating the behavior of hippocampal neurons, communities of 30,000 people, and nearly everything between. The contributions of Brady's students and colleagues reflect the diverse work of the man himself. Brady has fostered innovative research in behavioral pharmacology, physiology, behavioral medicine, and drug abuse treatment, and has himself conducted research addressing everything from physiology (e.g., Brady, 1958) to space flight (Hodos & Ator, 1994).

Choosing a few interesting or representative articles to review for *JABA* readers was a difficult task. Unlike many *JEAB* issues, much of the re-

search contained in this issue involved human subjects and addressed topics that either directly constitute or have clear implications for applied research. We settled eventually on four articles (DeGrandpre, Bickel, Higgins, & Hughes, 1994; Kelly, Foltin, Emurian, & Fischman, 1994; Lamb & Henningfield, 1994; Silverman, Mumford, & Griffiths, 1994) that do not focus on particular topics in behavioral medicine or behavioral pharmacology, but have implications or provide examples relevant to two issues of importance to nearly all applied researchers: (a) the study of private events and self-reports and the relations of both to other behaviors and (b) the study of multiple operants.

Private Events and Self-Reports

Three articles have implications for a scientific approach to studying private events. Lamb and Henningfield (1994) address private events most directly by administering different drug stimuli and examining the relations among several self-reports of privately observable drug effects and other non-verbal operants. Their 5 adult male subjects were experienced in self-administering opiates and stimulants, but were not currently physically dependent

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on any drug. Subjects received four agents: *d*-amphetamine, methamphetamine, hydromorphone, and placebo. The latter is, of course, the standard inactive control comparison in drug research. The remaining drugs were selected based on previous research examining stimulus discrimination and subject reports of drug effects associated with them. The amphetamines were selected because drugs in the stimulant class are easily established as discriminative stimuli in a wide variety of species (Kamein, Bickel, Hughes, Higgins, & Smith, 1993) and are reliably associated with particular patterns of subject reports (Preston & Bigelow, 1991). Hydromorphone was the opiate drug selected because the pattern of subject reports associated with this drug is less consistent. It tends to set the occasion for some reports that are typical for drugs belonging to the stimulant class and some that are typical of drugs belonging to the opiate class, yet experienced drug users can readily identify appropriate drug doses as belonging to distinctly different drug classes. Lamb and Henningfield also examined a range of doses for each drug. Again, based on previous work examining subject reports after administration of different doses of these drugs, they selected doses that were likely to produce clear reports about drug effects and doses that were likely to produce minimal reports.

During discrimination training, subjects were administered 30 mg of *d*-amphetamine or placebo and were told that they could earn extra money by pressing the green lever if they received Drug A (*d*-amphetamine) or by pressing the red lever if they did not receive Drug A. In addition to this nonverbal operant, subject report measures were collected before and after drug administration. These measures were computer administered and involved a well-established questionnaire (Addiction Research Center Inventory, ARCI) asking the subjects whether or not they were experiencing specific drug effects that have been found to be associated with different drug classes; having subjects rate effects such as drug liking, good drug effects, bad drug effects, and drug strength on analogue rating scales; asking subjects to identify the drug received as most like one of 14 different drugs; and having them

indicate which of 14 drug effects they were experiencing.

The amphetamines occasioned dose-related increases in *d*-amphetamine-appropriate responding, whereas hydromorphone did not. Amphetamines also occasioned dose-related increases in reports of the drug being most like "speed," whereas hydromorphone did not. However, both amphetamines and hydromorphone occasioned dose-related increases in reports of drug liking and in three scales of the ARCI. Thus, some self-report measures were well correlated with responding on the drug-appropriate lever and some were not. Lamb and Henningfield (1994) suggest that self-reports are complexly controlled by both the private event and the subject's history of experience with the drug. Some of the self-reports they observed (e.g., feels like speed) are probably occasioned by a relatively narrow range of stimuli because in the subject's experience with drug administration, these reports have been more selectively reinforced by the verbal community relative to other reports (e.g., drug liking). They also suggest that these results imply that private events do not necessarily mediate drug-produced reinforcement, because some reports of private events (e.g., feels like speed) correlate better with the nonverbal operant studied than do those that are assumed to mediate reinforcement (e.g., drug liking). Although this is an interesting speculation, their subjects provided these self-reports in the context of a discrimination task rather than under conditions of a self-administration study that would allow examination of reinforcing functions of the drugs. However, whether stimulant identification mediates discriminative responding or whether both the identification and discriminative responding occur independently as a result of drug discrimination remains to be determined. Nonetheless, Lamb and Henningfield's inclusion of self-report measures and examination of their relation to nonverbal operants provide excellent examples of ways to examine and conceptualize relations among private events, verbal responding, and nonverbal responding.

Although Lamb and Henningfield's (1994) study did not demonstrate that private events do not

necessarily mediate drug-produced reinforcement, the data of Kelly et al. (1994) do appear to support this view. They examined multiple indices of the reinforcing effects of Δ^9 -tetrahydrocannabinol (THC), the principal pharmacological agent associated with impairment following inhalation of marijuana smoke. Marijuana cigarettes containing varying doses of THC (0% to 3.5%) were made available to adult male subjects who reported regular marijuana use and volunteered to participate in a residential laboratory study. Dependent measures included the number of cigarettes smoked at each dose, the subject's preference between different doses, and written ratings of drug liking. The number of cigarettes smoked was unrelated to THC content, although subjects showed preference for cigarettes highest in THC content and ratings of drug liking were consistently higher when cigarettes containing THC were smoked. As such, one non-verbal operant (cigarette choice) was consistent with ratings of drug liking, and another nonverbal operant (number of cigarettes smoked) was not. This supports Lamb and Henningfield's conclusions that self-reports of drug liking do not necessarily mediate drug-produced reinforcement and that these behaviors are probably complexly controlled by both private events associated with drug effects and the subject's history of experience with the drug.

Silverman et al. (1994) provide another example of excellent methodology and conceptualization of the study of private events. This study does not focus on self-reports of private events, but it does provide an important illustration of how arrangement of the consequences for responding can alter discrimination of a private event. The purpose of this study was to develop a method for measuring the within-session onset of discriminative responding to the private stimuli of caffeine effects. Based on previous research with nonhumans showing a gradual onset and offset of physiological and behavioral caffeine effects and on research with human subjects examining physiological, self-report, and nonverbal behavioral effects, Silverman et al. were able to assume a gradual time course of effects and to estimate onset of caffeine's effects within 15 min of drug administration. Session length was ap-

proximately 75 min (15 min before and 60 min after administration). Under double-blind conditions, caffeine-abstinent adult subjects were given capsules containing either 178 mg of caffeine or placebo and were immediately asked to guess which substance they had been given. Guessing occurred on experimenter-controlled discrete trials in which subjects pressed a left- or right-side button corresponding to each substance. They also had the option to press a center "no-guess" button. No feedback was provided during the session, but immediately after each session, subjects were told which substance they had received. Subjects always earned \$0.10 for each correct guess. Experimental conditions involved altering a point-loss contingency (\$0, -\$0.10, or -\$1.00) for incorrect guesses. The procedure provided orderly data on the within-session onset of caffeine versus placebo discrimination. The point-loss contingencies (i.e., -\$0.10 and -\$1.00) delayed the discrimination time course. Silverman et al. suggested that providing the no-guess option and manipulating contingencies for incorrect guessing influenced guessing such that discriminative behavior came under better control; that is, the point-loss contingency diminished differential reinforcement for high-rate responding not under the control of the discriminative stimulus.

Examination of these complex interactions between private events and other behaviors has been facilitated by research in behavioral pharmacology. Drugs can serve as excellent stimuli for the study of private events because they can be controlled by the experimenter. The biochemical, physiological, and behavioral research has led to a good understanding of the pharmacokinetics of many drugs. For most drugs and routes of drug administration, we know about how easy or difficult it is for the drug to reach the bloodstream and brain and about how much time it takes to get there. We also know when to expect that the last traces of the drug will disappear from the system. In addition, for most drugs and routes of drug administration, we know when some of the observable behavioral effects typically appear and disappear. As such, we can make fairly accurate guesses about the likely onset and offset of private events associated with drug ad-

ministration. Also, dose–effect curves of drugs are well established with nonhumans before human administration is ever attempted, and for many drugs dose–effect curves are well established with human subjects. Thus, we generally know what doses of a drug are likely to have little physiological and behavioral effect, how much is likely to have a large effect, and, quite importantly, whether certain doses are likely to be dangerous or deadly. Finally, behavioral pharmacology research, probably because of the influence of a relatively mentalistic medical audience, has regularly included “subjective effects” as a measure. Hence, standard measures are available, as are substantial data on subject reports of private events associated with drug administration. This accumulated knowledge makes the study of private events associated with drug administration much easier. In designing a study, researchers can make fairly accurate guesses about when to begin measuring the private events, how often to measure, and how long to run the session. They can make good judgments about what type of stimulus to present. Because this type of research has emphasized measuring and studying different levels of the independent variable, researchers can make good guesses about what amount or intensity of the variable they should use. And because there are a number of well-established and *acceptable* measurement systems to monitor the type and intensity of self-reports about private events occasioned by a variety of drug effects, behavioral pharmacologists have been able to examine interesting relations among these self-reports, environmental factors, and other observable nonverbal behaviors.

Although excluding or ignoring self-report data was probably adaptive for applied behavior analysis during its early development, Skinner (1945; see also 1972, p. 382) clearly emphasized that any complete account of human behavior must include an analysis of private events such as thinking and feeling. Many behavior analysts have discussed the theoretical importance of private events in behavior analysis (e.g., Malott, 1989, pp. 299–301; Poppen, 1989, pp. 325–357), but little empirical work has been conducted in this area, and even less has

been reported in *JABA*. Subject reports about private events have occasionally been included in research published in *JABA* (e.g., Cinciripini, Epstein, & Martin, 1979; Fitterling, Martin, Gramling, Cole, & Milan, 1988; Lake, Rainey, & Papsdorf, 1979; McMichael & Corey, 1969; Williams, 1979), some studies have focused on developing methods of measuring or detecting private events (e.g., Boyle & Greer, 1983; Woolcock & Alferink, 1982), and the practice of asking consumers of behavioral interventions about the acceptability of the intervention (i.e., social validity assessment) has probably increased (cf. Schwartz & Baer, 1991) since Wolf first made a “case for subjective measurement” (1978, p. 203) in applied behavior analysis. Nonetheless, inclusion of subject reports about private events does not appear to be the rule in *JABA* research, and it seems safe to suggest that we have not systematically studied private events such that we have gained the understanding that Skinner (1945) suggested was important. That is, we do not have the ability first to specify stimulating conditions under which particular private events are emitted and second to understand the consequences that maintain the specific relations between responses and stimuli (cf. Skinner, 1972, p. 373). Although this may appear to be material for the human operant laboratory rather than for applied settings, clearly many of the problems that are regularly brought to practicing psychologists are expressed in terms of private events (e.g., anxiety and depression). As well-trained behavior analysts, we have tended to look beyond self-reports of private events to discover reliable and observable relations between behavior and environment. Indeed it might be said that studies published in *JABA* are more likely to ask two people to independently rate a subject’s observable signs of private events (e.g., pain, anxiety) than to ask the subject directly. Behavioral observation with good interobserver reliability has been a powerful, useful, and important strategy, and we do not mean to suggest that it should be abandoned in favor of self-reports. What remains unclear is why the collection of self-report data has been so minimally utilized. This practice has prevented us from gaining understanding of an

interesting behavior (i.e., self-report) and its relation to other behavior and environmental factors. Our reluctance to gather self-report data probably has also minimized our applied research on a host of interesting topics (e.g., pain, anxiety, depression, marital problems) and made our interventions less acceptable to large segments of the population (e.g., noninstitutionalized adults). Clinical psychologists have provided a host of standard measurement systems for collecting relevant self-reports on many of these problems. It is up to us to include them as dependent measures and to be careful to examine and talk about these data in a manner consistent with a natural science of behavior. In addition to adding a new and interesting dimension to our research, inclusion of these measures may increase the acceptability of our interventions and open up applied behavioral research to new areas of application. Direct practical gains could also emerge. As a concrete applied example, some recent work by Van Etten, Higgins, Budney, Bickel, and Hughes (1994) examined the utility of a "Pleasant Events Scale" (PES) (Lewinsohn & Graf, 1973; MacPhillamy & Lewinsohn, 1974) in determining whether cocaine abusers experience a lower density of reinforcement in their natural environment than do nonabusers. They found that abusers scored significantly below norms on occurrence of pleasant events but significantly above norms on enjoyability ratings. This suggests that although abusers have a lower density of nondrug reinforcement, they enjoy nondrug activities when they engage in them. Increasing the density of alternative nondrug reinforcement has proven to be an effective strategy in the treatment of cocaine abuse (Higgins et al., 1993). The PES could be a useful tool in behavioral assessment of clients entering cocaine treatment and in choosing behaviors that are likely to enter a natural community of reinforcement. It has already been successfully used in research on the behavioral treatment of depression (Lewinsohn & Graf, 1973; MacPhillamy & Lewinsohn, 1974). Another possible use for this type of graded self-report may be in the construction of reinforcer menus. Asking a subject to rate the "pleasantness" of items on the

menu may improve our ability to choose effective reinforcers for our subjects.

Whereas Lamb and Henningfield (1994) provide an example of the general benefits of employing self-reports and examining their relation to nonverbal operants and the environmental factors that control both, Silverman et al. (1994) provide important methodological lessons. Silverman et al. suggested that their procedure could be used to examine the influence of other behavioral factors (e.g., instruction, reinforcement) on drug discriminations or pharmacological factors such as tolerance, but this procedure need not be confined to the behavioral pharmacology laboratory. The inclusion of a "no-guess" option would be useful in measuring the onset of other discriminations, of either public or private stimuli. For example, this could be very useful in developing auditory testing procedures for verbal or nonverbal subjects. In behavioral medicine applications, it could allow more precise procedures for detecting the onset of headache pain. An additional benefit of Silverman et al.'s procedure is that it showed that reports about a private stimulus (i.e., the onset of a drug effect) can be modulated by environmental events. The more self-report data that we collect, the more we may come to appreciate the complex control of verbal behavior occasioned by both private and public events.

Multiple Operants

Although all the research we have reviewed above addresses multiple operants and their relations to each other, Kelly et al. (1994) provide an explicit example and important methodological lesson regarding multiple operants that has recently emerged from research in behavioral pharmacology. Kelly et al. and other studies assessing the reinforcing effects of drugs (e.g., Chait & Zacny, 1992; Foltin & Fischman, 1992) have indicated that multiple dependent measures are necessary for a more complete understanding of a drug's function. The importance of this methodological consideration is underscored by understanding that assessment of a drug's reinforcing effects predicts its abuse liability, and this, in turn, can influence regulation and avail-

ability of new medication agents. If Kelly et al.'s data represented the results of an abuse liability assessment of a new medication, and number of self-administrations taken was the only dependent measure examined, one might conclude that the medication was unlikely to be abused. However, if drug choice and ratings of drug liking had been the only dependent measures collected, one could conclude that the medication had a high abuse potential. Abuse liability assessment research has only recently begun to appreciate the complex relations among different operants and to investigate their implications. Although assessment of abuse liability is a socially relevant application of multiple operant methodology, there are many nonpharmacological applications of equal social relevance. For example, behavior analysts working in academic settings have noted that "on-task" behavior and task completion are two operants that do not necessarily correspond well, and most studies have begun to measure and report multiple dependent measures related to academic performance (e.g., Gardner, Heward, & Grossi, 1994; Kamps, Barbetta, Leonard, & Delquadri, 1994; Miller & Kelley, 1994).

The last of the four articles we chose to review provides an elegant example of the benefits that can be gained from examining multiple operants and their interrelations. DeGrandpre et al. (1994) used behavioral economic concepts to assist in understanding these relations. Reviewing behavioral economics, however, is beyond the scope of this essay; thus, we concern ourselves only with the procedures and results (see Bickel, DeGrandpre, & Higgins, 1993, for a review). DeGrandpre et al. studied the effects of different response requirements on two operants: self-administration of cigarette puffs and self-administration of money. The response requirement for these operants was also manipulated by systematically varying the fixed-ratio (FR) schedule for one operant (FR 100, FR 1,000, and FR 2,500) while keeping the schedule for the other operant stable (FR 100). Increasing the FR size for either operant decreased its consumption, with a greater decrease occurring for money. The effects of FR size also differed across

the two operants. Although greater responding occurred for money at the lowest ratio employed, increases in FR size decreased responding for money and increased responding for cigarette puffs such that at the higher ratios examined, greater responding occurred for cigarette puffs. Finally, increasing the FR size for one reinforcer had little effect on the consumption of the other concurrently available reinforcer. This study has two important implications for applied research. First, it demonstrates the need to examine responding maintained in multiple contexts. If the two reinforcers employed in this study were examined only at the lowest ratio, one might conclude that money was a more potent reinforcer than cigarette puffs. However, the opposite conclusion would be reached if they were examined only at the higher ratio. As a concrete applied example, imagine that during the early spring, a manager determines that the employees on the loading dock maintain higher work rates when offered financial bonuses contingent on work rate than when offered time off. The manager implements bonuses as a standard procedure for reinforcing high work rates. This procedure works well until summer arrives and the temperature and humidity on the loading dock climb. Now the response cost of the work has increased and the financial bonuses do not seem to be working as well. In this new context, time off may serve as the more effective reinforcer for maintaining higher work rates. Besides evaluating the relative efficacy of reinforcers in different contexts, the procedure used by DeGrandpre et al. provides a useful context for evaluating interactions between concurrently available reinforcers. Such analysis may, for example, have some utility for studying treatments of drug dependence that engage patients in alternative activities to drug use (e.g., Higgins et al., 1993).

Summary

JEAB's special issue celebrating the contributions of Joseph V. Brady has much to offer to *JABA* readers. Much of the research contained in this issue involved human subjects and addressed topics that either directly constitute or have clear implications for applied research. We chose to re-

view four studies that had implications or provided examples relevant to two issues of importance to nearly all applied researchers, but *JABA* readers would be well served to give this issue direct examination. Other articles address important issues of clear social relevance, including operant approaches to rehabilitation medicine and behavioral programs for entire communities.

Recently, one of us commented to Dr. Brady that we were impressed by the breadth of topics and approaches contained in this special issue. In his typical down-to-earth style, Brady shrugged and explained that he had simply set out to study everyone's dependent measure. He explained that he believed everyone from physiologist to space exploration scientist was ultimately interested in behavior. Therefore, he made it his business to understand the variables that were important in the control of behavior. Few scientists have done this so completely and so well.

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